DEC STD 103-0 Electromagnetic Compatibility (EMC) - Overview and Process Requirements

DOCUMENT IDENTIFIER: A-DS-EL00103-00-0000 Rev C, 11-Jul-1990

ABSTRACT: This standard introduces the electromagnetic compatibility (EMC) process, including the responsibilities of Design Engineering, the EMC Domain Manager, and other EMC groups. This document is to be used in conjunction with each of the detail sections of DEC STD 103.

APPLICABILITY: The requirements of DEC STD 103 (all sections) are mandatory for all hardware products marketed by Digital.

STATUS: APPROVED 11-Jul-1990; use VTX SMC for current status.

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1 EMC PROCESS

1.1 PURPOSE

DEC STD 103-0 through DEC STD 103-7 define the limits of electromagnetic interaction between any of Digital's hardware products and its environment in the area of Information Technology Equipment (ITE). It outlines measurement methodology, acceptability criteria, and responsibilities. The emission part of this standard aims to provide compliance with United States, Canadian, Japanese, and European (VDE) legal EMI requirements for ITE.

1.2 SCOPE

DEC STD 103 is an overview that defines the present scope and status of each detail section. It is mandatory for products marketed by Digital in standalone and system configurations. This revision supersedes DEC STD 103 Revision B, 29-Aug-1986. and divides that document into seven sections. The scope, applicability, and approval status of these documents is defined in DEC STD 103-0. The requirements of each section become effective on their approval date unless specifically specified in the detail section.

1.3 RESPONSIBILITIES

The following persons and groups shall fulfill the requirements of DEC STD 103.

1.3.1 Design Engineering

The product engineering group is responsible for designing equipment to meet the requirements of this standard and for any ECOs that may result from this standard. The product engineering group is responsible for the following.

- Submitting the equipment and any ancillary devices needed for the proper execution of EMC test(s).
- Obtaining the (internal) approval statements and documents to support the objectives of the product requirements document and engineering specifications. These requirements may be further defined in the product requirements or engineering specification.

Typically, these responsibilities are contracted out to one of the EMC support groups in Digital.

1.3.2 EMC Domain Manager

The EMC Domain Manager is responsible for the following.

- Maintaining EMC product status.
- Interfacing to outside agencies, industry organizations, and DEC country regulatory managers with respect to EMC matters.
- Organizing EMC engineering and testing support in Digital.
- Arbitrating significant EMC-related issues between EMC groups and/or engineering groups.

1.3.3 EMC Groups

EMC groups in Digital are organizations (or parts of organizations) specifically chartered to provide EMC design, test, and/or consultation services to one or more design groups. EMC groups are typically aligned with major hardware design activities. The EMC groups provide the design and testing expertise for the design and in-system testing of Digital products to ensure compliance to the requirements of DEC STD 103 as well as the outside agency requirements defined herein. EMC groups are responsible for the following.

Maintaining EMC test facilities adequate for the normal product mix this group expects to test.

Executing the product/system test(s) in a professional manner, according to the requirements of this standard; keeping accurate records; and maintaining test data in standardized form.

Providing feedback to the design engineering group regarding potential EMC product improvements or cost reductions, where necessary.

EMC groups evaluate product ECOs for their potential impact with regard to DEC STD 103-0. This evaluation includes testing to determine the impact of significant changes such as changes in clock frequency, grounding, and (data) cabling.

The groups designate one engineer to represent this group in the EMC Domain Forum. This engineer is also the gatekeeper for approvals, waivers, and status concerning those products handled by that EMC group.

The EMC Domain Forum is a committee of EMC engineers, chaired by the EMC Domain Manager or designate, that works issues common to EMC groups.

2 OVERVIEW

The following summarizes the contents of each section of DEC STD 103 Electromagnetic Compatibility (EMC), and Table 1 shows the status of each section.

- *DEC STD 103-0 - Overview and Process Requirements*

  This standard introduces the Electromagnetic Compatibility (EMC) process, including the responsibilities of EMC design, the EMC Domain manager, and other EMC groups. This document is to be used in conjunction with each of the detail sections (DEC STD 103-1 through DEC STD 103-7).

- *DEC STD 103-1 - Electromagnetic Compatibility (EMC) - Documentation and Approval Process*

  This standard defines documentation requirements for the EMC process. It includes information on internal and external test records, EMC product labeling requirements, user information and manufacturer's compliance statements, the compliance approval process external to Digital, and registration/license numbers.

- *DEC STD 103-2 - Electromagnetic Compatibility (EMC) - Calibration of Test Facilities and Instrumentation, proposed*

  This standard defines test procedures and acceptance limits for the qualification of EMI test sites (facilities) and test instrumentation to be used in the EMC testing of Digital products. This document includes information on Open Area Test Sites (OATS), Absorber Lined Chambers, and various calibration methods.

- *DEC STD 103-3 - Electromagnetic Compatibility (EMC) - Electromagnetic Interference (EMI) Requirements*

  This standard defines Electromagnetic Interference (EMI) requirements for Digital products that comply with mandatory external EMI requirements (for instance in the US, Canada, European Community, and Japan). This document also includes information on the test methodologies and the internal (Digital) EMI approval process.

- *DEC STD 103-4 - Electromagnetic Compatibility (EMC) - Electromagnetic Susceptibility (EMS), proposed*

  This standard defines acceptable levels of Electromagnetic Immunity for Digital products against interference from radio and television transmitters and other electromagnetic equipment. It provides the test methodology and immunity levels aimed at compliance with the EC directive on EMC as well as additional Digital proprietary information.

  NOTE

  This section of DEC STD 103 is under development. Until it is available, Heading 4, Electromagnetic Susceptibility (EMS) Immunity Control, in DEC STD 103-0, Rev B, 29-Aug-1986, remains in effect. For convenience, the content of that heading is reproduced as Appendix A in this document, DEC STD 103-0, Rev C, 11-Jul-1990. The information in DEC STD 103-4, when released, will supersede the information here. Use VTX SMC to verify this document's availability. Contact your EMC Domain manager for the most recent information.

- *DEC STD 103-5 - Electromagnetic Compatibility (EMC) - Hardware Design Requirements for Electrostatic Discharge (ESD) Immunity, proposed*

  This standard defines the limits of electrostatic discharge effects on Digital's hardware products. The standard also outlines measurement methodology, acceptance criteria and responsibilities. After providing an overview of the subject, the standard describes the technical and internal reporting requirements of electrostatic discharge immunity.

  NOTE

  This section of DEC STD 103 is under development. Until it is available, Heading 5, Electrostatic Discharge (ESD) Control, in DEC STD 103-0, Rev B, 29-Aug-1986, remains in effect. For convenience, the content of that heading is reproduced as Appendix B in this document, DEC STD 103-0, Rev C, 11-Jul-1990. The information in DEC STD 103-5, when released, will supersede

the information here. Use VTX SMC to verify this document's availability. Contact your EMC Domain manager for the most recent information.

- *DEC STD 103-6 - Electromagnetic Compatibility (EMC) - Health and Safety Limits, proposed*

  To Be Defined

- *DEC STD 103-7 - Electromagnetic Compatibility (EMC) - Quality Process, proposed*

  To Be Defined

Table 1 shows the status of each section of DEC STD 103.

Table 1: STATUS OF DEC STD 103 SECTIONS

Document Number	Revision Level	Effective Date
DEC STD 103-0	Rev C	11-Jul-1990
DEC STD 103-1	Rev B	11-Jul-1990
DEC STD 103-2	Rev A	To Be Determined
DEC STD 103-3	Rev A	11-Jul-1990
DEC STD 103-4	Rev A	To Be Determined
DEC STD 103-5	Rev A	To Be Determined
DEC STD 103-6	Rev A	To Be Determined
DEC STD 103-7	Rev A	To Be Determined

APPENDIX A ELECTROMAGNETIC SUSCEPTIBILITY IMMUNITY

REPRODUCED FROM DEC STD 103-0 REV B, 29-AUG-1986, HEADING 4, ELECTROMAGNETIC SUSCEPTIBILITY (EMS) IMMUNITY CONTROL

4 ELECTROMAGNETIC SUSCEPTIBILITY (EMS) IMMUNITY CONTROL

The purpose of the following text is to define realistic electromagnetic immunity levels against the effects of radio and TV transmitters, as well as other electromagnetic spectrum pollution from industrial processes. The requirements that follow apply to all products designed and sold by Digital when mounted, installed, and/or integrated to the level of an actual user installation.

4.1 WAIVERS

Where requirements of this standard impose unreasonable burden(s) for the product, the engineering group may seek a waiver to all or part of these requirements.

Requests for such a waiver must be substantiated with problem statement(s), cost and time estimates to correct the problem, and must be agreed to by the EMC group, Manufacturing, Customer Services, and the EMC domain forum.

4.2 BROADBAND CONDUCTED EMI (POWERLINE TRANSIENTS)

4.2.1 Measurement Setup and Instrumentation

Testing shall be done on each power cable leading into a data processing system. External data connections to this system shall be terminated to simulate actual use. For modems (DF02, DF03), the telephone line interface does not have to be connected. The telephone line interface is tested according to FCC Part 68 at the modem level. Connect terminal interface cables (EIA, 20 mA) to a terminal. Multiple terminal interfaces (DZ11) need have only one terminal connected.

The power cables from the equipment under test shall be connected to the power mains through an isolation/coupling network. The recommended power line transient testers (Keytech, Shaffner NSG Series) are available with these networks included. For high current devices, a 50 ohm/50 µH Line Impedance Stabilization Network (LISN) can provide a suitable isolation and coupling network.

4.2.2 Test Procedure

On systems with multiple cabinets (multiple connections to the AC power mains), the test is performed on one cabinet at a time.

For single-phase power cords, the common mode test is between Phase, Neutral, and Ground; the differential mode test is between Phase and Neutral.

For three-phase power cords, the common mode test is between Phase 1, Phase 2, Phase 3, and Neutral, all with respect to Ground.

In the cases where an input RFI filter is present with sizable suppression capacitors between each phase and neutral, the test can be simplified by only connecting neutral and ground. For three-phase systems, the differential mode test is performed between neutral and each of the three phases in succession.

Testing is done with transients of both positive and negative polarity, and the timing of the transient shall be varied to cover 360 degrees of the power cycle.

4.2.3 Limits and Acceptability Criteria

For systems tested according to the procedure under subhead 4.2.2, each external power cord power interface shall accept a transient with a magnitude of 1000 V or an energy content of 2.5 Ws, whichever is less. The rise time of the transient voltage shall be less than 1 microsecond. Systems are considered acceptable after a suitable number of transients (100 pulses of each polarity with random phase displacement) on each power cord have caused no errors in the operation of the system. Errors that are automatically corrected by the system without operator intervention can be ignored if they disappear altogether when the transient magnitude is lowered to 600 V.

The transient voltage is the actual peak voltage over and above the normal AC voltage from the power source. It needs to be monitored during the test because of the loading effects of the unit under test. The maximum energy content can be calculated from the energy storage in the circuit that delivers the transient.

4.3 NARROWBAND CONDUCTED (CW INJECTION)

4.3.1 Test Setup and Instrumentation

Instrumentation:

a. Two or more CISPR-3 or 50 µH/50 ohm LISNs.

b. A 10 kHz to 30 MHz sine wave generator with modulation capability.

c. A linear amplifier with an internal impedance of 50 ohms, capable of delivering 3 Vrms into 50 ohms from generator.

Test Setup:
Each external power cord of the system under test is plugged into a LISN. Where more power cords than LISNs are present, only the cord from the cabinet or device under test needs to go to its own LISN.

Each phase and neutral power line gets alternately connected to the sweep generator /amplifier combination with power line ground as reference (normal mode voltage connection). All unused LISN ports shall be terminated with 50 ohms.

4.3.2 Test Methodology

The frequency from the sweep generator is slowly varied (1 minute for a 10 kHz to 30 MHz sweep), with the output amplitude adjusted to deliver 3 Vrms into a 50 ohm resistive load. After the amplitude adjustment has been established, the 50 ohm load is replaced with the LISN connection to the unit under test.

4.3.3 Limits and Acceptability Criteria

The system under test shall not exhibit any failures during a full series of 5 sweeps per live power line and neutral on all the power cords entering the system, with an open circuit voltage of 6 Vrms (3 Vrms into a 50 ohm load) from the function generator and amplifier. The sweep time should be appropriate for the system under test and its response time also should be set to capture possible failures.

4.4 BROADBAND RADIATED TRANSIENTS

Digital currently has no requirement for radiated broadband noise testing. Efforts are underway to determine the need as well as proper limits and measurement methodology.

4.5 NARROWBAND RADIATED SUSCEPTIBILITY

4.5.1 Test Setup and Instrumentation

The test area and instrumentation required are as follows.

- An area wherein fields with a magnitude of 10 V/m can reliably and without adverse effects to radio communication be generated over the frequency range of 10 kHz to 1000 MHz.
- A variable frequency power source or sources that can power antennas or parallel plate structures over the required frequency range.
- A set of antennas reasonably matched to the available power sources.

Recommended Test Setup:

The recommended test chamber is a fully shielded anechoic screenroom with a means of illuminating the equipment(s) under test from all sides. A turntable provides the almost ideal setup. An anechoic room designed with FCC testing in mind (semi-anechoic) will have reflections due to the conductive floor. These reflections can be reduced by judiciously placing some ferrite tiles on the floor.

Other Test Areas:

Tests can be performed in less than ideal areas, using the skills and experience of the test engineer to compensate for some of the deficiencies. The results are usually subject to interpretation. Some possibilities are as follows.

- A parallel plate transmission lines suspended from the ceiling of a screenroom. The distance from the parallel plate to the ceiling of the shielded room is the main factor in determining the effective impedance of the parallel plate. In most cases the proper distance is determined experimentally while measuring with a time domain reflectometer (TDR).

The parallel plate will give an accurate uniform field for those frequencies where the size of the room cavity is small (less than 1/2 lambda) compared to the wave length of the generated field. A typical installation has a floor-to-plate distance of 2 meters, meaning that a 5 V/m field can be generated by an amplifier capable of delivering 2 W(rms) (10 V into 50 ohms) up to the first resonant frequency of the room.

It is understood that for higher frequencies (such as over 50 MHz) the field distribution is no longer uniform, due to cavity resonances. But when this setup is used with a low power amplifier (4 W), acceptable testing can be achieved with a relatively low capital investment for susceptibility testing.

- A TEM-cell (for smaller products), which is essentially a self-contained parallel-plate test setup of usually smaller dimensions as defined above, usable to higher frequencies.

Setup for Radiated Narrowband Susceptibility Testing:

Equipment installation in the test area should simulate as closely as possible an actual user installation. When the RF power delivered into the test area can be limited to 4 watts, it is acceptable to have an operator in the test area during the test.

For testing of individual devices such as tape drives where the CPU and so forth is not in the test field, the disk and/or data cables have to be connected through the screen room wall. These connections usually need special attention in terms of shielding and filtering, with hardware not commonly available in Digital. Consult your EMC engineer for assistance in the definition and installation of such devices.

4.5.2 Test Methodology

The frequency of the source generator is slowly varied from 10 kHz to 1000 MHz while keeping the voltage on the parallel plate at the desired value (6 V for a 3 V/m field-strength where the plate is 2 meters from the floor).

For testing in anechoic rooms, the source level may have to be continually varied to accommodate the antenna gain factor(s) associated with the transmitting antenna(s). For the lower frequency ranges (up to 220 MHz), automatic leveling loops are available from various manufacturers.

If a continually variable frequency source is not available, the frequency may be varied in steps small enough to judge the system response, but never larger than those shown in Table 4. The signal shall be 100% amplitude modulated with a 1000 Hz square wave.

Table 4. Test Frequency Steps

Frequency Range	Frequency Step
10 kHz to 300 kHz	10 kHz
300 kHz to 1 MHz	30 kHz
1 MHz to 3 MHz	100 kHz
3 MHz to 10 MHz	0.3 MHz
10 MHz to 30 MHz	1 MHz
30 MHz to 100 MHz	3 MHz
100 MHz to 300 MHz	10 MHz
300 MHz to 1000 MHz	30 MHz

Even though discrete frequency steps are suggested in Table 4, the actual frequency has to be adjusted to find the maximum sensitivity of the product in cases where problems such as clock or data rates are found or suspected.

4.5.3 Limits and Acceptability Criteria

The system under test is considered acceptable when it passes one full test without errors (even recoverable ones) with each of the four sides exposed to the whole frequency range at the specified level.

It is recommended that the test normally be done with higher levels, preferably at least 10 V/m if conditions permit and that the levels only be lowered if actual errors occur. The higher levels should be reported and documented if the system(s) passes.

Frequency (MHz)	Limit
.01 to 1000 MHz	3 V/m, average value

REPRODUCED FROM DEC STD 103-0 REV B, 29-AUG-1986, HEADING 4, ELECTROMAGNETIC SUSCEPTIBILITY (EMS) IMMUNITY CONTROL

APPENDIX B ELECTROSTATIC DISCHARGE CONTROL

REPRODUCED FROM DEC STD 103-0 REV B, 29-AUG-1986, HEADING 5, ELECTROSTATIC DISCHARGE (ESD) CONTROL

5 ELECTROSTATIC DISCHARGE (ESD) CONTROL

The purpose of electrostatic discharge (ESD) testing is to determine the capability and limits of a device or system to withstand the effects of static discharges from human beings. This heading defines the levels of ESD events that Digital products must be able to withstand. These levels are based upon the environmental conditions under which the products are designed to operate.

Requirements under this heading address all functional systems or parts thereof, such as terminals. They are specifically not applicable to subsets such as modules, or equipment in repair mode.

This heading sets different design standards for office equipment, in which category are included all general purpose terminals, small bounded systems, personal computers, and word processing systems; and for EDP, under which fall larger systems and peripherals normally installed only in computer rooms where temperature and humidity are controlled.

In addition to specifying the ESD tolerance requirements, this heading describes the test configurations required to test each type of hardware, and the test method to be used.

5.1 TEST CONFIGURATIONS

5.1.1 Free Standing Units and Complete Systems

The unit or system to be tested shall be placed on, but isolated from, a conducting surface not smaller than 3 meters by 3 meters. This conducting surface shall be bonded to the power mains "earth" connection at the same physical point at which the unit or system under test obtains its green wire reference.

5.1.2 Table-Top Units

The table-top unit(s) to be tested shall be placed on a wooden table that stands 0.8 meters over a conducting surface of not less than 3 meters by 3 meters. This conducting surface shall be bonded to the power mains "earth" connection at the same physical point at which the unit or system under test obtains its green wire reference.

5.1.3 Rack-Mounted Units

The unit under test shall be rack installed. Also, the host or peripherals shall be installed in the rack to the extent that a minimum functional system is obtained. The rack shall be placed on, but isolated from, a conducting surface not smaller than 3 meters by 3 meters.

This conducting surface shall be bonded to the power mains "earth" connection at the same physical point at which the unit or system under test obtains its green wire reference.

5.1.4 Peripherals (to the Unit Under Test)

Units not under test, but which are required to produce the necessary functions of the unit under test, may be removed from the conducting reference plane. Interface cables (data or power) shall be spaced 10 cm over the conducting plane. These interconnecting cables may also be shielded, filtered, isolated, or otherwise treated for the purpose of this test.

5.1.5 Test Methods

The test instrument to be used is a Model ESD 255 equipped with a P255-1 probe. The tester is available from Andy Hish Associates. ESD testers from Shaffner and Electrometrics are also acceptable, but they will lead to a slightly more severe test due to the higher output currents from those devices.

Each area of the unit under test will be exposed to 20 successive static discharges of the specified magnitude.

For equipment that is totally surrounded by a non-conductive shell, and where it can be demonstrated that no arcs to conductive parts can be drawn at the specified voltage(s), the test will be done to a metal plate with dimensions of 30 x 60 cm. The test shall be repeated with this plate placed vertically at a distance of 30 cm to the sides and back of the equipment as well as directly under the equipment in the case of a table top unit. The metal plate must be provided with a bleed-off resistor of approximately 1,000 ohms.

All devices must be tested at each of the following voltages in the prescribed manner.

2 kV	8 kV
3 kV	10 kV
4 kV	12 kV
5 kV	15 kV
6 kV	

5.2 ESD LIMITS

5.2.1 Definition

The terms used to state ESD requirements are defined as follows.

Normal operator access areas: Areas of the equipment that the operator is expected to touch during normal operation.

Operator service areas: Exposed surfaces that are accessible to the operator to service the equipment, not including normal operator access areas. Operator service includes functions such as paper replenishment, changing disks or tapes, and removing jams.

Hard failure: The equipment exhibits behavior that is in error and requires operator intervention to correct the error.

Hardware failure: A malfunction that causes permanent equipment damage requiring parts repair or replacement to correct.

Soft error: An error that is automatically corrected and requires no operator intervention to correct.

NOTE

Product specific information relative to the above definitions shall be provided in equipment product specifications.

5.2.2 Limits

EDP Equipment:
Hardware products that are designed to operate in a controlled environment, specifically equipment designed to fall into DEC STD 102-1 *Environmental Standard for Computers and Peripherals - Temperature, Humidity, and Altitude Test Requirements*,Class A.

Office Equipment:
Hardware products that are designed to operate in an uncontrolled environment, specifically equipment designed to fall into DEC STD 102-1 Class B.

Normal Operator Access Areas:
Hard failures generated at voltages of 10 kV or less for EDP equipment or 12 kV for Office equipment or less are not acceptable.

Operator Service Areas:
Hard failures are permitted if these failures do not cause failures in other parts of the system. For example, an electrostatic discharge to a peripheral must not cause a CPU hard failure, and a discharge when loading a disk pack must not cause a failure in the adjacent disk drive.

Hardware Failure:
Hardware failures recorded at any voltage up to 15 kV are not acceptable.

Soft Errors:
Soft errors are permitted under all conditions.

SUMMARY LIMITS

a.	Hard failures	None permitted at or under:
	EDP equipment	10 kV
	Office equipment	12 kV
b.	Hardware damage	
	EDP Equipment	15 kV
	Office equipment	15 kV

REPRODUCED FROM DEC STD 103-0 REV B, 29-AUG-1986, HEADING 5, ELECTROSTATIC DISCHARGE (ESD) CONTROL

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